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QUICK CONNECTOR FOR HIGH PRESSURE APPLICATIONS

Background of the Invention

This application relates to coupling assemblies, and more particularly to a quick connector of the type for connecting a male member formed at the end of a tube in a hollow female connector body for high pressure applications.

In the automotive and other fields, one type of coupling assembly often utilized to provide a fluid connection between two components or conduits are quick connectors, which generally include a male member received and retained in a female connector body. Use of a quick connector is advantageous in that a sealed and secured fluid line may be established with minimum amount of time and expense.

A retainer is often used to secure the male member within the connector body. One such type of retainer includes a plurality of locking members which extend between a radially enlarged upset formed on the male member and an annular face defined in the connector body. The abutment of the retainer with the upset of the male member at one end and the annular face of the connector body at the other end prevents the withdrawal of the male member from the connector body. This type of retainer is prevalent in the art and has proven effective in many fluid line applications.

Nevertheless, such retainers have occasionally been prone to failure. Due to the need for the locking members to flex radially upon inserting the retainer into the connector body and inserting the male member into the retainer, the elements allowing the locking members to flex radially takes up the space for the contact surfaces of the locking members. One possible reason for the failure of the retainer is the elements allowing the locking members to flex radially may

break or facture when the retainer is inserted into the connector body or when the male member is inserted into the retainer. Failure may also occur due to insufficient contact of the locking members with the upset.

An O-ring is sometimes used in with a quick connector to create a seal between the male member and the connector. The O-ring is typically installed into the same cavity that accommodates the retainer. In such a configuration, the O-ring is located immediately axially inwardly of the retainer or separated by an annular spacer slidably mounted on the male member. Since the retainer is flexible and the O-ring is slidably linked with the retainer, the O-ring is able to slide slightly relative to the male member making such sealing interface unacceptable for high fluid pressure applications.

Brief Description of the Drawings

Fig. 1 is an exploded view of a fluid coupling in accordance to the present invention;

Fig. 2 is side view of the connector body illustrated in Fig. 1;

Fig. 3 is a front view of the connector body illustrated in Fig. 1;

Fig. 4 is a cross-sectional view of the connector body along line 4-4 as shown in Fig. 2;

Fig. 5 is a perspective view of the retainer illustrated in Fig. 1;

Fig. 6 is a side view of the retainer illustrated in Fig. 1;

Fig. 7 is a cross-sectional view of the retainer along line 7-7 as shown in Fig. 6;

Fig. 8 is a cross-sectional view of the retainer along line 8-8 as shown in Fig. 6;

Fig. 9 is a cross-sectional view through the fluid coupling illustrated in Fig. 1 as assembled;

Fig. 10 is a perspective view an alternative embodiment of a retainer in accordance to the present invention;

Fig. 11 is a side view of the retainer illustrated in Fig. 10;

Fig. 12 is a cross-sectional view of the retainer along line 12-12 as shown in Fig. 11; and

Fig. 13 is a cross-sectional view of the retainer along line 13-13 as shown in Fig. 11.

Detailed Description of the Drawings

Figure 1 illustrates a fluid coupling 10 in accordance to the present invention. The fluid coupling comprises a male member 12, a hollow female connector body 14, a retainer 16 for securing the male member 12 within the connector body 14 and an O-ring or sealing member 18.

The male member 12 is formed at the end of a hollow and rigid tube 20 which forms a part of a fluid line system. The tube 20 may lead to a component in a fluid line system, or may itself be a portion of a component in a fluid line system. The male member 12 includes a radially enlarged annular upset 22 formed at a given distance L_1 from the distal end. The male member 12 also includes a cylindrical portion 24 between the upset 22 and the distal end. The cylindrical portion 24 has a diameter approximately equal to the diameter of the tube 20. A portion of the male member 12, including the upset 22, is coated with Nylon to provide corrosion protection.

The female connector body 14 is illustrated in Figures 2-4. The female connector body 14 has a hexagonal outer surface 26 at one end and a threaded outer surface 28 at the other end. The threaded outer surface 28 is adapted to mate with the corresponding threading of a brake component or other high pressure fluid component.

As illustrated in Figure 4, the female connector body 14 is hollow and defines an axial bore 30 extending axially inwardly from an entrance 32. The entrance 32 is defined by a radially

inwardly extending rim 34 having an apex 36 and an axially inward annular face 38. The rim 34 is chamfered at the axially outward surface 40 to facilitate the insertion of the retainer 16 into the connector body 14. Axially inward from the rim 34 is a cylindrical surface 42. Axially inward from the cylindrical surface 42 is a cylindrical step 44 terminating at an annular surface 46. Axially inward from the annular surface is a reduced diameter cylindrical bore 48.

A radially outwardly groove or undercut 50 is formed on the surface of the reduced diameter cylindrical bore 48 at a given distance L_2 from the annular surface 46. The groove is defined by two shoulders 52 extending radially outwardly from the surface of the reduced diameter cylindrical bore 48 and a radially outwardly cylindrical surface 51 having a diameter D_4. The width W of the groove 50 should be sized slightly larger than the un-deformed cross-section diameter D_1 of the O-ring 18 (see Figure 1) allowing the O-ring 18 to be retained axially in both directions within the shoulders 52 of the groove 50. The axially outwardly shoulder 52 absorbs the fluid pressure experienced by the O-ring. The depth $(D_3-D_4)/2$ of the groove 50 should be slightly smaller than the un-deformed cross-section diameter D_1 of the O-ring 18 allowing a portion of the O-ring 18 to extend radially inwardly beyond the un-grooved surface 54 of the reduced diameter cylindrical bore 48. In addition, the un-deformed inner diameter D_2 of the O-ring 18 (see Figure 1) is smaller than the diameter D_3 of the un-groove surface 54 of the reduced diameter cylindrical bore 48. This assures that the O-ring 18 is able to create an effective seal between the connector body 14 and the male member 12. Furthermore, the distance L_2 between the center of the groove 50 and the annular surface 46 should be less than the distance L_1 between the distal end of the male member 12 and the center of the upset 22 (see Figure 1) to assure that the O-ring 18 surrounds the cylindrical portion 24 of the male member 12 once the male member 12 is fully inserted into the connector body 14.

The retainer 16 is illustrated in Figures 5-8. The retainer 16 includes a cylindrical ring 56 at a first axial end. The ring 56 has a forward facing surface 58 and a rearward facing surface 60. A bore 62 is defined in the ring 56. Four locking members 64 extend axially rearward from the ring 56. The locking members 64 are not connected at the second axial end. Four axially extending elongated slots 66 are defined between each of the adjacent locking members 64 and extend from the second axial end to the ring 56. The slots 66 allow the locking members 64 to flex radially relative to the ring 56. The ring 56 has a conical outer surface 68 to facilitate the insertion of the retainer 16 into the connector body 14. Each locking member 64 includes two columns 70 and a rear connecting beam 72 connecting the two columns 70 at the second axial end. The two columns 70, the ring 56, and the connecting beam 72 define a window 74. Each locking member 64 further includes a duckbill shaped flexible arm 76 extending axially forward from the connecting beam 72 between the two columns 70. Since the arm 76 is only connected to the remainder of the locking member 64 at the connecting beam 72, the arm 76 is able to flex radially relative to the remainder of the locking member 64. Each arm 76 has a front abutment surface 78, a first ramped top surface 80, a second ramped top surface 82, a rear abutment surface 84, a notch 86 defined on the ramped top surfaces 80,82, a ramped bottom surface 88, and a cylindrical flat bottom surface 90. The notch 86 allows the cross-sectional thickness of the arm 76 to be approximately equal, thus reducing the possibility of sinks or voids in the arm 76 during the molding process of the retainer 16.

It is desirable for the radial projection distance t_1, t_2 of each column 70 is sized to allow for the structural integrity necessary for the locking member to flex without fracturing, while also allowing the arms to have sufficient abutment surface areas to retain the male member in the connector body during high pressure applications. To accomplish these two goals, it is

preferable that the ratio of the radial projection distance t_1,t_2 of each column 70 relative to the outer diameter D_5 of the ring 56 (t_1/D_5, t_2/D_5) is between 0.03 and 0.12. It is more preferable that the ratio of the radial projection distance t_1,t_2 of each column 70 relative to the outer diameter D_5 of the ring 56 (t_1/D_5, t_2/D_5) is between 0.04 and 0.06.

To form the connection as illustrated in Figure 9, the O-ring 18 is first positioned within the groove 50 of the connector body 14. The retainer 16 is then inserted into the connector body 14. As the retainer 16 is inserted into the body 14, the first ramped top surface 78 of each arm 76 contacts the apex 36 of the rim 34. Further insertion of the retainer 16 axially inward flexes the arms 16 radially inward relative to the locking members 64 and also flexes the locking members 64 radially inward relative to the ring 56. After the retainer 16 has been fully inserted into the connector body 14, the arms 16 and the locking members 64 spring radially outward until the rear connecting beams 72 of the locking members 64 abut the rim 34. In its fully inserted position, the retainer 16 is constrained radially and axially within the connector body 14. Abutment of the connecting beams 64 with the rim 34 and abutment of the ring 56 with the cylindrical step 44 constrain the retainer 16 radially within the connector body 14. Abutment of the forward facing surface 58 of the ring 56 with the annular surface 46 of the connector body 14 prevents the retainer 16 from further axially inward movement. Abutment of the rear abutment surfaces 84 of the locking members 64 with the annular face 38 prevents the retainer 16 from further axially outward movement.

With the retainer 16 fully inserted into the connector body 14, the male member 12 can be inserted into the body/retainer 14,16 assembly. As the male member 12 is inserted axially inward into the body/retainer 14,16 assembly, the upset 22 of the male member 12 contacts the ramped bottom surfaces 88 of the arms 76. Since the diameter of the upset 22 is greater than the

diameter of portions of the ramped bottom surfaces 88, further axially inward insertion of the male member 12 causes the arms 76 to spread radially outward. Once male member 12 has been sufficiently inserted axially inward for the upset 22 to surpass the arms 76, the arms 76 spring radially inward. With the coupling 10 in the locked position, the upset 22 is located between and in abutting relation with the rearward facing surface 60 of the ring 56 and the front abutment surfaces 78 of the arms 76. The male member 12 is constrained radially and axially within the retainer 16. Abutment of the cylindrical portion 24 of the male member 12 with the surface of the bore 62 of the ring 56 and with the bottom cylindrical flat surfaces 90 of the arms 76 constrains the male member 12 radially within the retainer 16. Abutment of the rearward facing surface 60 of the ring 56 with the forward surface of the upset 22 prevents the male member 12 from further axially inwardly movement. Abutment of the rearward surface of the upset 22 with the front abutment surfaces 78 of the arms 76 prevents the male member 12 from further axially inwardly movement. Since the retainer 16 is constrained radially and axially within the connector body 14, the male member 12 is also constrained radially and axially within the connector body 14.

For the purpose of describing the present invention of this application, the term "contact ratio" is used to represent the surface area of the forward abutment surfaces available for abutment with the upset compared to the surface area of an imaginary continuous surface linking and including the forward abutment surfaces. For the type of retainer illustrated in Figures 5-8, the continuous surface would be an annular surface. A continuous surface, having a contact ratio of 1, is not practical for the type of retainer illustrated in Figures 5-8 since the elements of the retainer allowing the locking mechanism to flex radially requires space. Therefore, the present invention balances the space required for the elements allowing the locking mechanism to flex

radially with the contact surface required for high pressure application. For the type of retainer illustrated in Figures 5-8, the contact ratio is the total surface area of the forward abutment surfaces 78 of the arms 76 relative to the area defined by the outer diameter D_6 of the forward abutment surfaces and the inner diameter D_7 of the forward abutment surfaces:

$$\text{CONTACT RATIO} = \frac{\text{total surface area of forward abutment surfaces}}{\pi^*(D_6/2)^2 - \pi^*(D_7/2)^2}$$

It is preferable that the contact ratio is over 50% and less than 70%. It is more preferable that the contact ratio is over 55% and less than 60%. It is understood that the total surface area of the forward abutment surfaces is not necessarily the total surface area abutting the upset, but merely the total surface area which will abut the upset if there is a perfect fit between abutment surfaces and the surface of the upset. The actual total surface area abutting the upset may be smaller due to at least; 1) the mismatch of the contour and/or size of forward abutment surfaces relative to the contour and/or size of the rearward surface of upset, and 2) the roughness of the surfaces of the forward abutment surfaces of the arms and/or the roughness rearward surface of the upset.

A second embodiment of a retainer 116 in accordance to the present invention is illustrated in Figures 10-13. The retainer 116 of the second embodiment is similar to the retainer 16 of the first embodiment with the exception that the notch 186 defined on the top surfaces 180,182 of the arm 176 has a U-shaped cross-section. The retainer 116 of second embodiment further includes a cylindrical extension 192 extending from the forward facing surface 158 of the ring 156. The cylindrical extension 192 provides additional inner surface area to constrain the male member 12 radially within the retainer 116. The retainer 116 of the second embodiment also has a portion of the arm 176, defining the second ramped top surface 182, connected directly

to the columns 170. The connection of a portion of the arm 176 directly to columns 170 provides additional structural integrity when the arm 176 flexes radially relative to the remainder of the locking member 164.

It is preferable that the plastic retainer is formed of polyethyethyerketone, also known as PEEK. A suitable PEEK for forming the retainer of the presentation is available under the trademark Victrex PEEK™ 450G.

Various features of the present invention have been described with reference to the above embodiments. It should be understood that modifications may be made without departing from the spirit and scope of the invention as represented by the following claims.